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Deformable MEMS grating for wide tunability

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Abstract

A deformable MEMS grating is presented. Electrostatic actuation allows a per cent tuning of up to 2.5%. This device can be used as tuning element in an external cavity mid-infrared Quantum-Cascade Laser.

Keywords: MEMS Grating, Tunable laser

Introduction

Tunable lasers are key elements in many systems, e.g. gas sensing and telecom. While multisection lasers are compact tunable sources, External Cavity Lasers (ECLs) have larger tuning ranges and are independent of the laser material.

In a standard MEMS-based approach to ECLs, tuning is achieved through a rotation of either the grating or a mirror associated with the grating. While controlled rotation of out-of-plane elements is used in existing MEMS based ECLs [1], a simpler solution is to deform the grating itself.

Deformable MEMS Diffraction Gratings do not require macroscopic motion, since only an in-plane stretching of the grating on the order of microns is required. Deformable MEMS grating have already been explored, but the proposed version extends considerably the tuning range compared to the current state of the art in the field [2]-[4].

This deformable MEMS grating can be applied to mid-IR (5-10 μm) external cavity Quantum Cascade (QC) lasers.

Design

Fig. 1 shows the deformable MEMS grating design, where flexible beams act as springs between the wider grating beams and anchor the structure to the substrate via an oxide layer. The grating is stretched by two comb actuators. The feasibility of the design was tested through finite element modeling which was used to simulate the in-plane movement of the structure. In this design only one mask level is used for the definition of the grating itself, the springs and the actuators.

Fabrication

Fig. 2 shows the process flow. The process starts from an SOI (Silicon On Insulator) wafer. The device layer thickness is 10 μm and guarantees sufficient stiffness to the entire structure.

Photolithography is followed by dry reactive ion etching. The device is then released by removing the sacrificial oxide in vapor HF.

Gratings with period of 6μm, 9μm and 12 μm have been realized. Fig. 3a) and 3b) show a top view and a cross-section, respectively, of one of the 6 μm period devices.

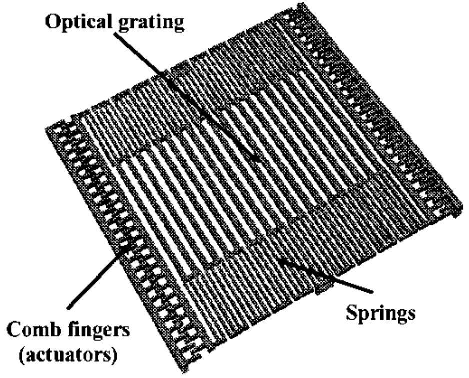

Figure 1. Deformable grating design.

Results

The deformable gratings were tested by applying up to 100V to the comb actuators. Fig. 4 shows a detailed view of the grating a) with no applied voltage, and b) with 100 V applied. In the latter case each end of the grating moves by about 2 μm, resulting in an overall stretching of the structure of 4 μm. In percentage terms, the grating period (ΔPeriod/Period) changes by ≅ 2.5%, corresponding to a tuning range of 120 nm at a wavelength of 5μm.

Fig. 5 shows the measured displacement of the comb actuator versus the applied voltage.

Conclusion

We have tested deformable MEMS gratings that can be used as a tunable element in mid-IR (5-10μm) external cavity Quantum Cascade (QC) lasers.

Theoretical maximum efficiency for the first diffraction order is 40%.

Acknowledgements

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References

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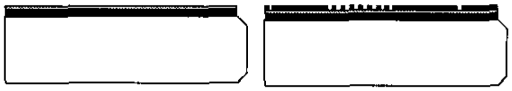
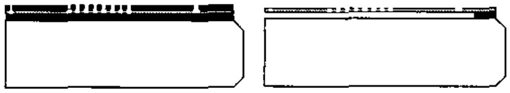


a) Start with SOI wafer b) Patterning of structures



c) Dry etching of device Si d) Remove of sacrificial oxide in HF

Figure 2. Process flow.

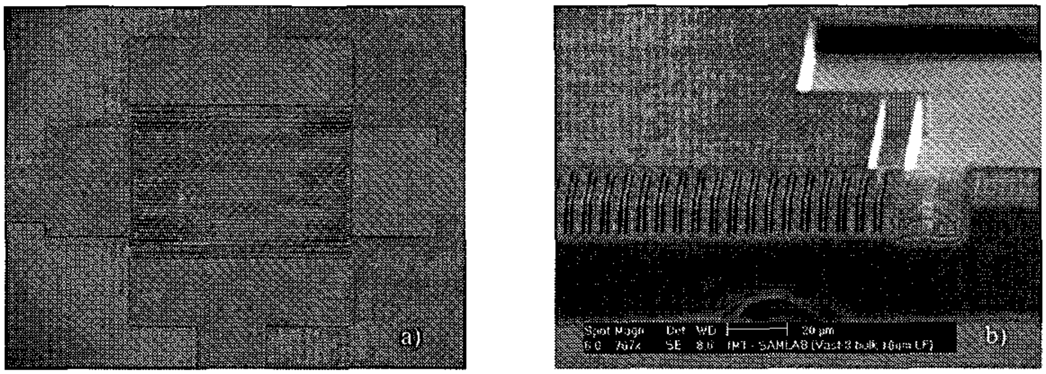


Figure 3. Fabricated device. a) Top View (optical microscope). b) Cross-section SEM image of the springs.

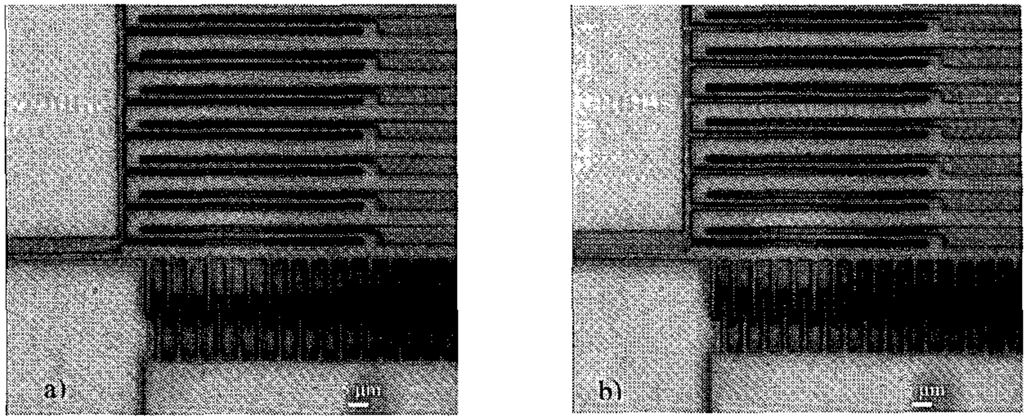


Figure 4. Electrostatic comb drive and springs: a) No applied voltage. b) 100V applied

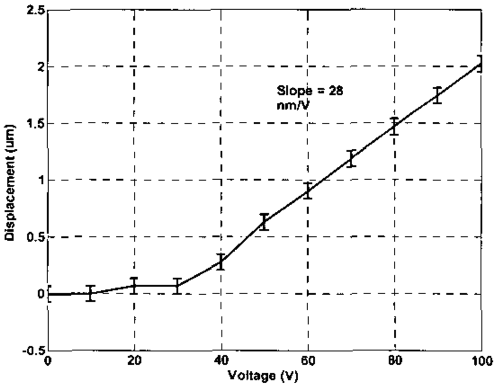


Figure 5. Measured displacement (µm) versus applied voltage.